

Laurentella, a new subgenus of Trombiculid Mites, with notes on biology and medical importance

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Euschöngastia indica (Hirst 1915), described from a bandicoot rat¹ from Calcutta, was shown during World War II to be extremely widespread in south-east Asia. It is the commonest, and often the sole, trombiculid mite to be found on house-rats, roughly in the area bounded by India, Sumatra, New Guinea, Guam and Philippines. Recent collections have shown that this is a member of a fairly large group, and the 'indica-group' (Womersley 1952:237; IMR 1953:65) was provisionally discussed as "new subgenus" of *Euschöngastia* by Audy (1954b:154). It is now possible to distinguish this group from some related groups showing convergence in the larvae. The group shows characters which distinguish it at least at a subgeneric level from the type, *Schöngastia sciuricola* Ewing 1925, of the genus *Euschöngastia*; it is therefore here described as a new subgenus.

The subgenus has considerable biological interest because of the occurrence of one species (*E. indica*) as a widespread urban chigger, and of another (*E. audyi*) as the dominant chigger on tree-living mammals in the Malaysian forests; while some species are endoparasitic in the nasal cavities of rodents. It is of great taxonomic interest because, together with the genera *Ascöschöngastia* and *Pseudöschöngastia*, it appears to form part of a complex involving a number of controversial characters. The biology of the group and its potential medical importance are discussed below.

Genus *Euschöngastia* Ewing, *sensu lato*

Laurentella new subgenus

Type-species.—*Schöngastia indica* Hirst, 1915:187, Bull. ent. Res., 6, 183-90. Common and widespread, especially on rodents (including house-rats) in the Asiatic-Pacific area.

*Diagnosis**.—Those trombiculid mites described as the 'indica-group' by Audy (1954b:154) which have hitherto been included in the genus *Euschöngastia* Ewing 1938, after Wharton & Fuller 1952:73, but are distinguished in the larval stage by possessing the following characters: *Scutum* small subquadrate, lightly chitinated, with AW 20-50 μ and AP 20-35 μ ; in the typical group (i.e. excluding *debilis*-group), AM is anterior to ALs with the shoulders of the scutum prominent and rounded in front of ALs; AL setae shorter than AM, PLs usually longest; anterior scutal margin usually sinuous.

¹ The bandicoot rats, *Bandicota* (*Nesokia* or *Gnomys* of many authors), are rodents of the Oriental region and must be distinguished from the marsupial bandicoots of Australasia (e.g. *Echymipera*, *Isodon*). According to Blanford in the *Fauna of British India*, the name bandicoot is of Indian origin, from the Telugu *pandi kokku* ("pig-rat") given by tank-diggers, and is consequently correctly applied to the rat rather than the marsupial.

* Account has been taken of some undescribed species in framing this. Standard abbreviations are used, as follows: AL-AM = anterolateral, anteromedial scutal setae; SB = sensillary bases or line between them; ASL = anterior scutal length in nymph or adult, from level of SBs to fectal seta, roughly equal to length of crista.

posterior margin convex may be flattened or indented in the midline; sensillary bases about centrally placed, little more than their diameter apart; sensillae expanded but only occasionally globose; in the *debilis*-group the AM seta is in line with or posterior to the line of ALs and the anterior scutal margin is slightly sinuous and without AL shoulders, and the posterior margin is concave. *Eyes* 2+2, 1+1, or apparently absent. *Gnathosome*: palpal setae not strongly developed, with a few small barbs or nude, the femoral seta being appreciably shorter than either genual or dorsal tibial; palpal claw 2- or 3-pronged, modified especially in endoparasitic forms so as to be basally thick and strongly incurved (cf. claws of *Dolaisia*); chelicerae also variable, occasionally modified in endoparasitic forms so as to be reduced and with a blunt dorsal tooth (cf. *Dolaisia*); galeal seta typically nude, but with a few barbs in the *debilis*-group. The palpal tarsus bears the usual tarsala plus 6 ordinary setae (5 in *debilis*-group), one of which may be nude (in *debilis*-group and some intranasal species); the subterminal solenidion is absent.

Legs short, especially leg II, with relatively thick stumpy segments; segmentation 7.7.7 although the division of the femora especially of leg II is frequently indistinct; leg III with genuala and tibiala, and often with one or more nude setae (mastitarsalae), tibia and tarsus of leg III in the intranasal *TAA*-group enlarged (thickened) and with an exaggerated modified seta near the pretarsus. *Setae* of scutum, palps, body, and legs delicately barbed or nude, not stout or plumose, and broadly related to the general degree of chitinization; all setae on body, legs, scutum, and galea more strongly developed and barbed in the *debilis*-group. *Larvae* of intranasal forms showing slight constriction of the body when engorged; preferring mammals and especially rodents in forest, but may be found casually on birds; occasionally endoparasitic (intranasal). *Distinguished* from larvae of subgenus *Helenicula* Audy by the presence in the latter of SBs less than their diameter apart and ratio PW/SB over 5 (under 4 in *Laurentella*). AM shorter than ALs or subequal and its base not anteriorly placed, and with tarsala and microtarsala I subterminal (closely adjacent to subterminala), and the 2 tibialae I also being placed distally, roughly in a line with the microtibiala. Distinguished from larvae of *Axeoschöngastia* Ewing, sens. str., and *Pseudoschöngastia* Lipovsky by the placing of the PL setae on the scutum. Distinguished from larvae of *Dolaisia* Ouds., sens. lat., by the 3 (not 2) genualae I, the presence of a tibiala III and of AL shoulders on the scutum.

Nymphs and Adults (so far described only for *indica*, *audyi*; but known for 5 other species including intranasal forms, from Malaya and Borneo) apparently not distinctive, of general *Euschöngastia* facies with ASL:SB ratio almost 2; sensillae generally well-barbed or plumose distally, with well-developed shafts (thickened in *audyi*). (Studies of postlarval stages are not yet sufficiently advanced for useful comparisons to be made).

Distribution so far known, essentially Oriental and Australasian, extending to Ethiopian region (one species, undescribed) and to Palearctic (one species in Japan).

Remarks.—The writer has pleasure in naming this subgenus for Dr. R. F. Lawrence, Director of the Natal Museum, South Africa, who has pioneered the proper study of African trombiculids and to whom he is very grateful for the most friendly collaboration in the study of African material.

The subgenus as here envisaged takes account of some material which is to be described in collaboration with Traub in future issues of "Malaysian Parasites", continuing "Malaysian Parasites I-XV" (*Stud. Inst. med. Res., Malaya*, 26, 1953, issued

1954). Sufficient details are here described or drawn to explain emendation of the diagnosis, while the opportunity is taken to give some comparative details of *E. rattus*, *E. debilis*, and *E. sp. nr. labuanensis* (Fig. 1). *Euschöngastia debilis* represents an atypical species-group described below and provisionally included in this subgenus: it appears to provide a link with the genus *Pseudoschöngastia*.

The monograph on the type-species, *E. (L.) indica*, by Wharton (1946) is one of the most complete accounts of any species of trombiculid yet published.

List of Species

The following species are here placed in this subgenus. Data already given in the excellent checklist of Wharton & Fuller (1952:40) are brought up to date and some comments added. Their indications of the type of contributions made by the papers concerned are used again here in the hopes that other compilers of checklists will do the same; these indications are: a—atomy, b—biology, m—medical, t—taxonomy, v—veterinary, to which we add s—synonymized, l—in a checklist, and N,A—nymph, adult discussed.

Ellerman (1949) and Ellerman & Morrisson-Scott (1951) are taken as the authority for names of host-species in the following list, the names of hosts as actually recorded by authors being shown in parenthesis after the currently accepted name.

New records are added particularly from the following collections, summarized in Audy (1954a). (1) MALAYA, 1948 onwards: by Colonial Office Scrub Typhus Research Unit, described in detail by Audy & Harrison (1954), where also other collections are referred to. (2) BORNEO—SARAWAK 1950–1952: largely by the above unit with Tom Harrisson, Government Ethnologist and Curator, Sarawak Museum, for whose hearty collaboration we are very grateful; and also by an expedition into the interior in 1950 with the added collaboration of the U.S. Army Medical Research Unit in Malaya (Traub). (3) BORNEO—NORTH BORNEO, expeditions in 1951, 1952, 1953: jointly by U.S. Army and Colonial Office Unit teams with U.S. Army financial support, as described by Traub & Audy (1954a). (4) INDIA: by Lt-Colonel Sardari L. Kalra, including the collections described by Womersley (1952), which were registered, mounted, and sorted by us, selected series being sent to Womersley. (5) THAILAND: A collection from Thailand has been made through the co-operation of Robert E. Elbel of the U.S. Special Technical and Economic Mission to Thailand, and through the offices of the Thai Division of Communicable Diseases, particularly Dr. Pramern Chandavimol, Chief of the Division, and Dr. Mali Thaineua, Director of the Banpeng Plague Laboratory. The records of *E. audyi* from Thailand in this paper, relating to specific hosts, have kindly been provided by Lt-Colonel Robert Traub, to whom the writer is also grateful for a number of records from Borneo. Unidentified hosts recorded for *E. indica* from Thailand are derived from an early collection from near Bangkok sent to us, of which host identities have not yet been checked. (6) HONG KONG, 1949–50: by J. D. Romer, Municipal Rodent Control Officer.

A. *Euschöngastia indica* species-group

1. *Euschöngastia (Laurentella) indica* (Hirst)

Type-species of subgenus; type in British Museum (Nat. Hist.) London.

Schöngastia indica Hirst, 1915:187(d); Walsh 1927; Gunther 1941; Finnegan 1945; Wharton 1946; Wharton & Carver 1946; Thor & Wiltmann, 1947; Fuller 1948; Gispén 1950a,b (cm).

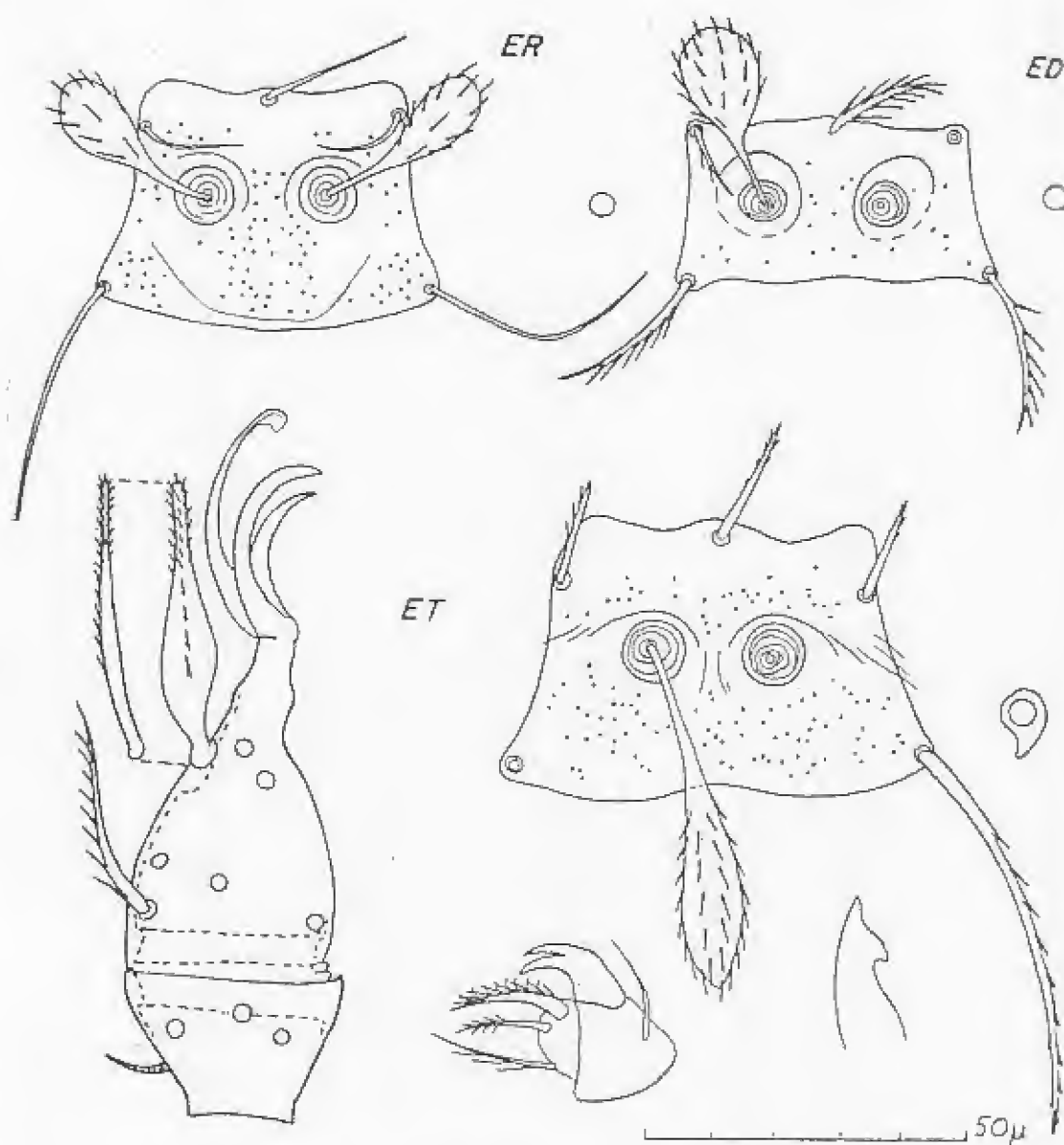


Fig. 1. Details of species of *Laurentella*. ER (after Domrow)—*Eusehngastia* (*Laurentella*) *rattus* (Womersley & Heaslip) (*indica*-group), scutum redrawn to scale from a drawing by Mr. R. Domrow, of a specimen of *rattus* from *Rattus assimilis*, Mt. Glorious, South-east Queensland, 6.viii.1951. ED—*Eusehngastia* (*Laurentella*) *debilis* (Gater) (*debilis*-group), scutum and eyes, specimen from a *Crocidura*, forest in Selangor. ET—*Eusehngastia* (*Laurentella*) 'TAA' (*TAA*-group), scutum, eye, palpal claw and tarsus, chelicera, and part of leg III. The elongate sensilla, short curved palpal claw, and toothed chelicera resemble the same parts of *Doloiisia*, but other species provide intermediate links with typical *Laurentella*. The inflated tarsus and tibia III is observable as a tendency in other species in the *debilis*- and *indica*-groups (*debilis* also has tarsus I subglobular).

Schöngastia indica, Toomey, 1921:606(1).

Neoschöngastia indica, Gater, 1932:156(c,t); Gunther, 1941; Heaslip, 1941; Radford, 1942; Womersley & Heaslip, 1943; Blake *et al.*, 1945; Buitendijk, 1945; Finnegan, 1945; Takekawa, 1945; André, 1946; Philip *et al.*, 1946; Radford, 1946; Taylor & Murray, 1956; Wharton, 1946; Wharton & Carver, 1946; Mohr, 1947; Gunther, 1952:26(1).

Axoschöngastia indica, Wharton, 1946:151-84(abc); Philip & Woodward, 1946; Griffiths, 1947; Jenkins, 1947; Brennan, 1949(a); Lipovsky, 1950.

Euschöngastia indica, Fuller, 1948:107(1); Audy, 1949(c), 1953:154(1); Philip *et al.*, 1949; Philip & Traub, 1950; IMR 1950:64(c), 1952:50(b), IMR 1953:65; Wharton & Fuller, 1952:77(1); Audy, Thomas & Harrison, 1953(c); Audy & Harrison, 1954:17(c); Traub & Audy, 1954:67(m); Traub & Evans, 1954:103; Harrison, 1954:181(b); 1956(h); Radford, 1954:264.

Euschöngastia sp. near *indica*, Audy, 1950:193(c).

Schöngastia (*Axoschöngastia*) *indica*, Womersley, 1952:208(d); 378(Nd,c), 2c (corrigendum).

Trombicula muris, Walch, 1922:34(d), 1923; Fletcher *et al.*, 1928(dc); Hayakawa & Hokari, 1946; Hayakawa *et al.*, 1944. [Synonym of *E.(L.) indica*; homonym of *Trombicula* (*Neotrombicula*) *muris* (Ouds.)].

Trombicula indica (*muris*), (sic), Patton & Evans 1929:655; Mehta 1937:359.

Neoschöngastia muris, Radford, 1942:76(1), 1946.

Euschöngastia muris, Radford, 1954:265(1) (also listed as *E. indica*).

Neoschöngastia cockingsi Radford, 1946:262(d); Fuller, 1952:186(is), Womersley, 1952:208(ds).

Axoschöngastia cockingsi, Ewing 1946.

Euschöngastia cockingsi, Wharton & Fuller, 1954:75; Radford, 1954:264.

Axoschöngastia Monteli, André, 1954(d); Le Gac *et al.*, 1954(d). New synonym.

Previous Records.—INDIA & CEYLON. Rodents: *Bandicota bengalensis* (also recorded as *Nesokia* or *Gunomys bengalensis*); *Rattus* *r. bullocki* (*R.r. brunneusculus*, *R.r. rufescens*), *R.r. kandianus* (*R. kandianus*). Insectivore: *Tupaia glis* (*T. belangeri*). Carnivore: mongoose, *Herpestes*. Bird: *Rhodophila ferrea*, a chat (*Turdidae*). MAL-DIVE IS.: *R.r. alexandrinus*? (*R. norvegicus norvegicus*, but see Harrison & Audy 1951:176). Note: Records of *R. rufescens* and *R. nitidus* by Radford (1946) were of provisional field identifications, the identification being published later as *R.r. bullocki* Roonwal (1949), which Ellerman & Morrison-Scott (1951:583) consider to be a form of *brunneusculus*. BURMA: *B. bengalensis*; *R.r. khyensis*. SUMATRA: *Rattus rattus* subsp. (*R. diardi*, *R. jalorensis*). MALAYA: *R.r. diardi*, *R.r. jalorensis*, *R.r. argenti-venter*, *R. exulans* (*R. concolor concolor*); *R. whiteheadi*, *R. sabanus*, *R. canus* (*R. malaisian*). JAVA: *R.r. diardi*, *R. norvegicus*, *R. exulans* (*R. concolor*); shrew, *Suncus murinus* (*Pachyura murina*). INDOCHINA, around Saigon: *R. norvegicus* (*R. decumanus*), *R. fulvexens*? (*Mus jersoni*, sic!). PHILIPPINES: *R.r. alexandrinus*, *R. norvegicus*. NEW GUINEA AREA: "Rats"; *R. exulans* (*R. calcis*), *R.r. mindanensis* (*R. mindanensis*), *R. ringens*. GUAM: *R.r. mindanensis*. QUEENSLAND: *R. fuscipes assimilis* (*R. assimilis*) from Cairns (2 specimens identified as *indica* by Womersley; Heaslip coll.—this record requires confirmation).

New Records.—The following records for *E. indica* (and also, below, for *E. audyi*) are hitherto unpublished. Casual hosts, only occasionally and lightly infested, are shown in parenthesis. Some details of infestation in Malaya are given by Audy & Harrison (1954:17, Table 3). MALAYA: The most heavily infested animal so far found is the semi-arboreal *Rattus rattus jalorensis* from a mature oilpalm estate, with nearly 40 mites per rat (though this same species in the forest fringe has many fewer, averaging 3 per rat in our collections, but with a higher proportion of *audyi*); next are domestic rats in towns and villages including Singapore, Kuala Lumpur, Klang, Port Swettenham

and Port Dickson, both *R.r. diardii* and (in certain seaports) *R. norvegicus*, with 10–20 mites per rat; then the squirrel *Callosciurus tenuis* (about 10 per squirrel, but see section on biology, below) in secondary forest or forest fringes; in small numbers on *Rattus exulans* and the tree-rat *R. cremoriventer*, and on tree-shrews, *Tupaia glis* and *T. minor*. (Also recorded from *R. rattus argentiventer*, *R. annandalei*, *R. bowersi*, *R. canus*, *R. mülleri*, *R. sabanus*, *R. whiteheadi*, *C. notatus*, *C. caniceps*, *C. lowii*, *C. nigrovittatus*; domestic civet, *Paradoxurus hermaphroditus*; slow loris, *Nycticebus concinnus*, and a single specimen taken on two occasions on the giant pill-millipede, *Sphaeropacium globus-magicus* Jeekel from an aboriginal village, Dusun Wani, Bukit Lanjun Forest Reserve, Selangor—these millipedes were mostly found round rotten logs and were freely infested by *Siseca subrata* Audy, 1956, and the infestation by *indica* was obviously by stragglers, probably from some nearby rat's nest. The first record from a millipede was reported by Audy (1950). BORNEO—(a) NORTH BORNEO: Only on *R.r. diardii* in and near houses in Jesselton (coast) and Bundu Tuhan (Kinabalu area), 1951–54. Not collected in the uninhabited area of Mt. Trus Madi east of Keningau, 1954. (b) SARAWAK: In moderate numbers on *R.r. diardii* and *R.r. jalorensis* (Also recorded on *R. whiteheadi*, *C. notatus*, *C. prevosti* from Kuching area). HONG KONG: On *R. norvegicus* from town, 1949–50. THAILAND, neighbourhood of Bangkok; common on many animals. All hosts have not been identified but *indica* has been identified in collections sent by R. Elbel from rodents, *Bandicota indica* and *B. bengalensis* (a new record of this host, Harrison 1956), *Rattus rattus* subsp., "field rats", "ground squirrels" (including *Menetes herdmorei*), "grey squirrel", "tree squirrel" (including *C. nigrovittatus*); from insectivores, "shrew", "tree-shrew" (*Tupaia*); and from carnivores, "civet cat", "mongoose" (*Herpestes*). INDIA—(a) MANIPUR (Imphal area): *R. r. bullocki* from in and near villages (Audy *et al.*, 1953) (also on a *Tupaia glis* and a mongoose, *Herpestes* sp.) (British Army Scrub Typhus Research Laboratory coll.). (b) PENINSULAR INDIA: House-rats from Bombay, Mysore City, Jubbulpore, Bangalore, Mehandar, and Sundarbani; shrew (probably *Suncus murinus*) Mehandar; gerbil, *Tatera indica*, from Sundarbani (S.L. Kutra, collection sent to the writer). INDIAN OCEAN, CAR NICOBAR: 22 specimens on 2 out of 5 rats, dark-bellied form of *R. rattus*, village 'store', x.1950 (*C. A. Gibson-Hill coll.*, see IMR 1952:47).

Remarks.—Dr. Marc André sent the writer specimens of his species *monteli* from Saigon. These fall within the range of variation of *E. indica* and *Ascoschöngastia monteli* André is therefore considered here to be a synonym of *E. indica*. *E. indica* may well be a polytypic species and several published forms may prove to be subspecies; judgement must however be reserved, e.g. in the case of *E. (L.) rattus*, below.

2. *Euschöngastia (Laurentella) audyi* (Womersley)

Schöngastia (Ascoschöngastia) audyi Womersley, 1952:205(d), 363(Nd), 2a (corrigendum). *Euschöngastia indica*, Traub *et al.*, 1950(m) (identification amended in Traub & Audy, 1954:77).

Euschöngastia species "S", Audy & Harrison 1951:390.

Euschöngastia audyi, IMR 1952:93(c); Audy *et al.*, 1953, Traub & Audy, 1954:77(m), 81(c). Audy, 1954b:154(t); Harrison, 1954:181(b); Radford, 1954:264(1).

Remarks.—First collected from towns in South Burma, where it occurred in small numbers on rats, this species has since been found a dominant chigger on arboreal mammals, especially squirrels, in the rain forest of Malaya and Borneo. The larva is orange-red in colour (that of typical *indica* being white). Womersley (1952:206) gave

the type data as follows: "Loc. and Host. Described from the type, from Prome, S. Burma, 1945 (no host and further date recorded) and from 6 paratypes from *Rattus rattus norvegicus* [sic] from R.G.N. Pagoda Rd. S. Burma, 14-16 Sept., 1945 (coll. T. J. Lawrence, type PII, paratypes 702-4, 706-4, 708-1). Also 7 specimens from *R.r. norvegicus* from Toungoo, S.B. 23 Oct., 1945 (768)". There are confusing errors here partly corrected by Womersley on his p.2a. The correct data, from our records (J.R.A.) are as follows: Described from the type, from *Rattus rattus khyensis* Hinton, Prome, S. Burma, 29.ix.1945; 6 paratypes from same host species, Pagoda Rd., Rangoon 14-16.ix.45; also 7 specimens from same host, Toungoo, 23.x.1945 (G. W. Ash & J. R. Audy coll.). The collection was part of a survey of South Burma, an account of which is still to be published (details are at present available only in Audy 1947, and to some extent in Audy *et al.*, 1953).

Traub *et al.* (1950) recovered *Rickettsia tsutsugamushi*, the infective agent of scrub typhus, from forest chiggers which were provisionally identified and cited as *E. indica*, but which were subsequently identified with *E. audyi*.

Previous Records.—SOUTH BURMA: *Rattus r. khyensis*, MALAYA: *Callosciurus nigrovittatus*, *C. notatus*, from forest.

New Records (see comments under *E. indica*).—MALAYA: Dominant in the forest on squirrels, *C. nigrovittatus* (about 40 mites per squirrel), *C. notatus* & *C. tenuis* (10-15 mites); and in small numbers (1-5 per animal) on *C. caniceps*; on tree-shrews, *Tupaia glis* & *T. minor*; on tree-rats, *R. canus*, from forest and *R.r. jalorensis* from forest fringe. (Also recorded on *R. annandalei*, *R.r. argentiventer*, *R.r. diardii*, *R. rajah surifer*, *R. sabanus*; *C. lowii*; ground-squirrels *Lariscus insignis* and *Rhinosciurus laticaudatus*; insectivore, *Hylomys suillus*; flying-lemur, *Cynocephalus variegatus*).* BORNEO.—(a) NORTH BORNEO: In largest numbers on squirrels, *C. notatus* (especially from Kabajang, coastal village in Beaufort area; and in Beaufort area), *C. adamsi* (especially at Mt. Trus Madi, near Keningau, recorded as Ulu Kaingaran). (Also recorded from squirrels, *Callosciurus prevosti*, *C. lowii*, *Dremomys everetti*, *Nannosciurus whiteheadi*, and the tree-shrew *Tupaia tana*, from the Kinabalu and/or the Trus Madi areas, by the joint U.S. expedition). (b) SARAWAK: In largest numbers on a few squirrels collected upcountry, viz. *C. notatus*, *C. prevosti*. (Also on *R.r. argentiventer*, *R. mülleri*, *R. whiteheadi*, *C. notatus*, ?*C. prevosti*; *Nannosciurus whiteheadi*; and *Tupaia minor*, *T. tana*, in the Kuching area). THAILAND, Bangkok area: *Rattus r. thai* from Muang Lampaya (37 from 4 rats) 24.vi.1952, and Ban Pong, and Pakrad, vi.1952; *Rattus rattus* ssp. from the City (Nakhon Ratchasima district) 11.viii.1952 (this urban occurrence was noted by the writer in Burma but is uncommon in Malaya among urban rats in large towns); *Callosciurus* spp., *C. notatus miniatus*, *C. erythraeus* ssp. (personal communication, Traub).

3. *Euschöngastia* (*Laurentella*) *daria* Traub & Audy

Euschöngastia daria Traub & Audy 1954:81(d); IMR 1952:93(1) (no. 46).

Records.—BORNEO (Mt. Kinabalu): Tree-shrews, *Tupaia montana batuensis*, *T.m. minor*; dwarf ground-squirrel, *Nannosciurus whiteheadi*; bird (chick of an unidentified ground-bird).

* Also on *Rattus alticola* in Pahang (Brinchang Hill, Cameron Highlands), 19.vii.1948 (Traub, personal communication).

4. *Euschöngastia* (*Laurentella*) *indicella* Traub & Audy

Euschöngastia indicella Traub & Audy 1954:77(d); IMR 1953:93.

Records.—BORNEO (Mt. Kinabalu): Tree-mouse, *Chiropodomys legatus*.

5. *Euschöngastia* (*Laurentella*) *kitajimai* Fukuzumi & Obata

Euschöngastia kitajimai Fukuzumi & Obata 1953:15(d); Sasa & Jameson 1954:261(d).

Records.—JAPAN: *Rattus rattus* s.sp. from Miyake Island.

Remarks.—This species is very close to *E. indica* and may prove to be a geographical subspecies.

6. *Euschöngastia* (*Laurentella*) *lorius* (Gunther)

Neoschöngastia jimangi Gunther, 1938:204(m); Takekawa 1945, 1939 [nom. nud.].

Neoschöngastia lorius Gunther, 1939:281(d); Womersley 1939; Gunther 1940, 1942; Radford 1942; Womersley & Heaslip, 1953; Taylor & Murphy, 1946; Gunther 1952:30(1).

Euschöngastia lorius, Wharton & Fuller 1952:78(1); Radford 1954:265(1).

Records.—NEW GUINEA: Bird, *Lorius loratus*.

7. *Euschöngastia* (*Laurentella*) *ocellifera* Traub & Audy

Euschöngastia ocellifera Traub & Audy 1954:79(d); IMR 1952:93 (no. 49).

Records.—BORNEO (Mt. Kinabalu): Tree-mouse, *Chiropodomys legatus*.

8. *Euschöngastia* (*Laurentella*) *rattus* (Womersley & Heaslip)

Neoschöngastia rattus Womersley & Heaslip, 1943:118(d); Taylor & Murray, 1946; Mohr 1947(c); Wharton & Fuller, 1952:77(1s); Gunther, 1952:132 (1); Radford, 1954:266(1).

Schöngastia (*Ascoschöngastia*) *rattus*, Womersley, 1952:207(d).

Euschöngastia indica, Wharton & Fuller, 1952:77(1s).

Euschöngastia rattus, Audy, 1954:154(1); Radford, 1954:32(1).

Records.—AUSTRALIA (QUEENSLAND): *R. fuscipes assimilis* (*R. assimilis*) from Imbil and Brisbane. NEW GUINEA (?): *R. ringens* from near Sansapor—see below.

Remarks.—The existing descriptions are inadequate and existing drawings show some discrepancies, so that the exact status of this form is difficult to decide. A specimen kindly lent to the writer by Womersley (labelled: Paratype Schon. (Ascosch.) *rattus* W & H on *R. assimilis*, Brisbane, Q. 5.4.39, W.G.H.), shows that the exceptional scutal depth (AP 42 μ) which has been recorded may be an error due largely to fracture of the scutum, visible under phase contrast in the paratype examined; this may also explain discrepancies between the various published drawings of the scutum. Fig. 1 shows a normal scutum (Domrow, see below). It is noteworthy that both *indica* and *rattus* were recorded from a collection made near Sansapor by Mohr (1947). Identifications were apparently made or confirmed by Womersley. *E. rattus* was recorded as from 2 per cent of *R. ringens*, 5 per cent of *R. exulans* and from only one specimen *R.r. mindanensis*. This collection is not referred to by Womersley in his monograph (1952). These identifications require confirmation. There appear to be sufficient morphological grounds for distinguishing this form from *indica*, although further studies of material from Queensland may suggest it is, for example, an Australian or Australasian subspecies now overlapping with introduced *indica*.

Since this paper was drafted, Mr. R. Domrow of The Queensland Institute of Medical Research has kindly sent a description of a single specimen of *E. (L.) rattus* in his collection, taken from the type host *Rattus assimilis*, Mt. Glorious, 6.viii.1951 (E. H. Derrick coll.) and identified by Womersley. Mr. Domrow has kindly allowed his comments to be quoted: the scutum is not fractured and the standard measurements are, AW 38.6, PW 52.6, SB 19.3, ASB 19.2, PSB 20.3, SD 39.5, AP 28.1, AM 28.4, AL 17.6, PL 45.6, Sens 31.6. Anterior scutal margin concave with slight convexity near AM base; AL 'shoulders' normal; posterior margin gently convex. The scutal setae are very fine, especially apically. Pupal formula N.N.N.N.N, claw slender (15.7μ) and longer than palpal tibia, DS fine and whiplike, resembling scutal setae, without distinct barboles (those of *indica* are more robust). VS small and much more numerous than in *oudyi* or *lorius*. Mr. Domrow considers that *rattus* is distinct from *indica* and most closely resembles *lorius*, differing in various features such as the stumpy palpal claw and few VS in the latter.

9. *Euschöngastia (Laurentella) roluis* Traub & Audy

Euschöngastia roluis Traub & Audy 1954:79(d); IMR 1952:93 (no. 48).

Records.—BORNEO (Mt. Kinabalu): Tree-mouse, *Chiropodomys legatus* (with *E. (L.) indicella*).

10. *Euschöngastia (Laurentella) soekaboemiensis* (Takekawa)

Trombicula soekaboemiensis Takekawa, 1954(d).

Euschöngastia soekaboemiensis, Hayakawa, 1946; Hayakawa & Hukari, 1946; Gunther, 1952:33(1).

Schöngastia (Aeschöngastia) soekaboemiensi, Womersley, 1952:212(d).

Euschöngastia soekaboemiensis, Wharton & Fuller, 1952:82(1); Audy, 1954:154; Radford, 1954:266(1).

Records.—JAVA: *R.r. diardii*, *R.r. jalorensis*, (*R.r. roquei*). SOUTH BURMA: *Bundicota bengalensis* (*Nesokia bengalensis*); *Rattus r. khyensis* (*Rattus rattus norvegicus*, *R.r. nr. khyensis*).

Remarks.—A species from South Burma (and fairly common there) was identified by Womersley with Takekawa's species (which was adequately described in Japanese but of which no material has been seen). As Womersley describes (pp. 209–211), the Burma series can be distinguished satisfactorily from *E. indica*. The fact that *E. soekaboemiensis* has not yet been found in extensive collections in Malaya but appears to occur both north (Burma) and south (Java) of it is not exceptional because there is a faunal and floral barrier running across the extreme north of Malaya through Langkawi island and Kedah, and a number of insects, reptiles, amphibians, and mammals have been recorded north and south of Malaya but not in the body of the peninsula (see Zeuner 1941; Reid, 1950; Harrison, 1956). The assumption is that *E. soekaboemiensis* is to be added to the list of arthropods (butterflies and mosquitoes) showing a latitudinal break in distribution across the body of Malaya.

Womersley (p. 213) appears to identify *soekaboemiensis* with *cockingsi* by inference; but *cockingsi* is a synonym of *indica*, and the confusion was due to misidentification in the field. Fuller (1952:188) has clearly identified *cockingsi* with *indica*; so also has Womersley (1952:208). It is worth noting that the Arakan Yoma mountain range and the Chindwin river are effective zoogeographical barriers well known to mammalogists and ornithologists. The Imphal plain, type locality of *cockingsi* (*syn.*), is in

the intervening mountain mass, and although it could have species of trombiculids introduced from either side, its general faunal affinities are on the Indian and not the Burmese side.

Womersley's data for the South Burma material are partly corrected on his p. 26. *E. soekaboemiensis* was found to be fairly common on urban rats, *Bandicota bengalensis* and *Rattus r. khyensis*, in and on the outskirts of 9 villages and towns visited by me. It appeared to be filling the same niche in company with *indica*.

B. *Euschöngastia debilis* species-group

11. *Euschöngastia (Laurentella) debilis* (Gater)

Neuschöngastia debilis Gater, 1932:160(d); Radford, 1952; Womersley & Heaslip, 1941; Takekawa, 1945; Taylor & Murray, 1946; Thor & Willmann, 1947; Fuller, 1948.

Euschöngastia debilis Fuller, 1948:108(1); Wharton & Fuller, 1952:75(1); Audy, 1954:154(1); Radford, 1954:264(1).

Schöngastia (Ascöschöngastia) debilis. Womersley, 1952:203(d).

Previous and New Records.—MALAYA: Originally from a tree-rat, *Rattus cremoriventer cremoriventer*. New records, showing the numbers of *debilis* obtained from forest in Selangor, are as follows: 1 on *Rattus annandalei*, 29.xi.1949; 3 on *R. mülleri*, 3.iii.1950; 1 on *R. sabanus*, 25.xi.1952; 1 on *R. jalorensis*, 1.vi.1948; 1 on *R. whiteheadi*, 10.ii.1950; 1, 3, and 3 from the shrew *Crocodyrus malayana* on 1.v.1953, 21.i.1954; and 7 from a water-shrew, 10.viii.1951. Most of these hosts are ground-animals and infestations are obviously casual, except possibly for the shrews. The sensillae are clavate.

12. *Euschöngastia (Laurentella) labuanensis* (Womersley)

Schöngastia (Ascöschöngastia) labuanensis Womersley, 1952:204(d), 2c (corrigendum).

Euschöngastia labuanensis, Radford, 1954:265(1).

Record.—NORTH BORNEO, Labuan (island off west coast): A rat ("a marsupial rat" in original, corrected in corrigenda; *Rattus* sp., erroneously by Radford).

Remarks.—Womersley's figures 53H and 53J are at variance with the text. Two species very close to this have been found in North Borneo by a joint expedition with the U.S. Army Unit—unfortunately only one specimen of each was obtained. Both have barbed or branched galeal setae. The sensillae are clavate.

The Species Groups

Three groups of species may be easily recognized. The *debilis*-group is included in this subgenus tentatively although no nymphs are available for study. The third group comprises species which are about to be described in collaboration with Traub. As discussed below in the section on affinities, *E. oculicola* (Wom.) may represent a fourth group in *Laurentella*. Finally, a tendency towards some widening of the scutum, together with a greater separation of the SBs, may be discerned, so that one should envisage the possibility of adding a group to accommodate such species with trapezoidal or roughly rectangular rather than subquadrate scuta. The groups are distinguished as follows on larval characters, but at any moment a species may be found which would require this simple diagnosis to be modified:—

1. AM seta anterior to line of ALs, with AL shoulders to scutum; posterior scutal margin convex, though perhaps very slightly; galeal seta nude; palpal claws with 2 or 3 prongs; 3 genualae 1

- AM seta level with or posterior to ALs, scutum without AL shoulders; posterior scutal margin concave; galeal seta barbed or branched (?nude in *labuanensis*); palpal claws 3-pronged; 2 genualae 1 (? invariable) *debilis*-group
2. Tibia and tarsus of leg III normal; species either ecto-parasitic or endoparasitic (intranasal) *indica*-group
- Tibia and tarsus of leg III swollen (fig. 1), with an exaggerated distal tarsal seta, endoparasitic TAA-group.

The following species, including those undescribed forms which have been sufficiently studied, are included in these groups, while an opportunity is taken to summarize distribution and add minor notes not available elsewhere in this paper. N.A. signify that nymphs/adults have been reared (but, except for *indica* and *audyi*, not yet described). Several additional species from Borneo and Malaya are being studied.

A. *indica*-group (15 species)

- E. (L.) audyi*, N. Common, arboreal animals, Malaya and Borneo.
- E. (L.) daria*, N. North Borneo, not uncommon. Once on a bird.
- E. (L.) indica*, N.A. Very common and widespread, especially on house-rats and semi-arboreal animals in forest fringe and plantations, Oriental and Australasian regions. Stragglers on a wide range of hosts.
- E. (L.) indicella*, N. North Borneo.
- E. (L.) kinujimai*, Island off Japan.
- E. (L.) lorius*, A bird, New Guinea.
- E. (L.) ocellifera*, North Borneo.
- E. (L.) rattus*, Australasia.
- E. (L.) rohuia*, N. North Borneo.
- E. (L.) soekaboemiensis*, Commensal (domestic and field) rats, South Burma and Java.
- E. (L.) "LUM"*, Vereammen-Grandjean, Mammal, Uganda. This species is typical except for coxa III which is 3-4 setose. It is the only representative of this subgenus out of nearly 200 African trombiculid species.
- E. (L.) "CAN"*, N. *Rattus canis*, Malaya.
- E. (L.) "CTEN"*, *Callosciurus tenuis*, Malaya.
- E. (L.) "LAU"* (38520), Intranasal, fairly common on *R. cremoricenter* in Malaya; once on *Callosciurus nigrovittatus*, Malaya.
- E. (L.) "NEW"*, Intranasal, rats in North Borneo (Traub coll.).

B. *debilis*-group (4 species)

- E. (L.) debilis*, Rare, Malaya; ?particularly on shrews.
- E. (L.) labuanensis*, Rat, Labuan off Borneo coast.
- E. (L.) "ALT-B"* (40592), One specimen, *Rattus alticola*, Beaufort, near coast opposite Labuan, North Borneo.
- E. (L.) "ALT-TM"* (40030), One specimen, *R. alticola*, Mt. Trus Madi, North Borneo.

C. TAA-group (3 species)

E. (L.) "TAA" (38669). N. Intranasal, occasionally on *R. rajah surifer*, Malaya.

E. (L.) "TBB" (38691). N. Intranasal, in large numbers (about 30 per rat) on *R. rajah surifer*; also on *R. rajah peltax*, and occasionally on *R. cremoriventer*, *R. whiteheadi*, *R. sabanus*, and *R. bowersi*, Malaya.

E. (L.) "TMM" (40008). N. Intranasal, fairly common on rats, Mt. Trus Madi, North Borneo.

Biology

Location on host.—Philip & Woodward (1949) noted that *indica* was the only urban trombiculid encountered by them, and that at least in Manila the larvae attached not only in the usual hollows in the outer conchae of the ears (a site of election for many species of trombiculids) but "along the whole external auditory canal". We have observed the same thing in Malaya, and also in Manipur, the larvae sometimes lying deep in the canal in a mucoid secretion. This habit is doubtless related to the development of intranasal endoparasitism, some species of this subgenus being found deep in the intranasal cavities of rodents, especially *Rattus rajah* (IMR 1954:57,83; Audy & Vercammen-Grandjean, 1955). At least one of these intranasal species appears to be common in North Borneo as well as in Malaya. There is a tendency for these intranasal forms to become less heavily chitinized and with less setal ornamentation generally, to have modified palpal claws and sometimes chelicerae, and also to develop a peculiar modification of the tarsus and tibia of leg III (Fig. 1). Species with the last-named character are here placed in a group (*TAA*) by themselves. Nymphs of several intranasal species from Malaya and Borneo have been reared; they show no particular characters distinguishing them from ectoparasitic forms. Serial sections of the nasal capsule of *R. rajah*, sometimes with as many as 15–20 larvae (including sp. "*TBB*") in one plane, show several larvae attached by chelicerae but no signs of the sucking tubes which trombiculid larvae characteristically develop. The larvae, most of which always appear to be engorged, move about freely in the intranasal mucus.

Feeding Times of Larvae.—Harrison (1954:181) found that the feeding-times of larvae identified as *E. indica* appeared to be bimodal, one group with a short feeding time ranging around 9 days, and another with an undetermined mean ranging above 12 days and possibly up to some weeks. He stated that "such an inconsistency may indicate different biological races, or a feeding time which varies with host behaviour . . ." The possible relationship of this finding with the red and white forms of *indica* (see *h* below) is being investigated. Wharton described larvae of *indica* on Guam as being "orange white to cream" and he reported feeding times of 10 to 32 days. Other miscellaneous references to feeding times of trombiculids are in Audy (see *Trop. Dis. Bull.*, 1948, 45, 66) and Wharton & Fuller 1952:18.

Habitat of Nymphs and Adults.—The free-living post-larval stages of *E. indica* have been recovered from coconut-palm tops in Addu Atoll, Maldives (Radford, 1946), where rats apparently nested; and particularly from nests of *R. mindanensis* in the bases of epiphytes in Guam by Wharton (1946), who stated that the free-living stages of *indica* were largely "restricted to runways, nests, and hiding places of *R. mindanensis* that were protected by some sort of cover". Nests in or near the ground were much less freely infested. Gispén (1950a) attempted to pick up chiggers by exposing rats as bait.

and while he failed to recover *indica* from rank grassy areas (alang), he recovered 3 larvae from rats exposed near rat-holes. These findings help us to interpret the host infestation data given below.

Host Relationships.—All the species of *Laurentella* appear to belong essentially to forest rodents, and to some extent insectivores, with the exception of *E. indica* which occurs in largest numbers in plantations and towns. The following hosts are principally involved—information about their habitat and behaviour may be found in Harrison & Lim (1950), Harrison (1954, 1957), and Harrison & Audy (1954).

i. **Commensal Animals.** Commensal animals are here taken to include all those which are encouraged by man-made conditions, either house-building or interference with natural vegetation to produce serral patches, gardens, and plantations. Domestic animals are a special group. Commensals generally include introduced species. In the case of *E. indica*, only commensal rats appear to be infested significantly.

(a) *Rattus exulans* (= *R. concolor*), and *Mus musculus* in Malaya. Both of these haunt houses, but the former is more frequent in scrub and grassland. They are notable for being generally very lightly infested by trombiculids. *R. exulans* in the field in Selangor carries equal numbers, about 1 per rat, of *E. indica* and *Trombicula deliensis*. In the town, it is negligibly infested by *indica*.

(b) *Rattus rattus diardii* and *Rattus norvegicus*, house rats. The number of *indica* found on house-rats in towns in Malaya, about 10–20 per rat, compares with the number given (16 per rat) by Gispen (1950a) for house rats in Batavia. He states that sewer-rats (*R. norvegicus*) appeared to be attacked more frequently than house-rats (*R.r. diardii*) in Batavia, 80 per cent and 31 per cent respectively being infested. Twenty-three *R. norvegicus* caught in Tjikini market were all infested, with about 20 *indica* per rat. In Guam, Wharton (1946) reported *indica* absent from 88 *Mus musculus* and 60 *R. exulans* from villages and open grassy areas and gardens nearby—the latter were apparently not infesting the houses significantly.

It is now well recognized that *E. indica* is a very widespread urban trombiculid, often the sole species on house-rats, over the whole of its range. Other species which also occur locally on urban rats are: *Trombicula munda* Gater, in small numbers on *R.r. diardii* in Kuala Lumpur; *E. (Laurentella) soekuboeniensis* on *R.r. khyensis* in Rangoon and other towns of South Burma; *Gahrliepia (Schöngastiella) ligula* (Rad.), in towns of South Burma and many parts of India (see Traub & Evans, 1954:102).

(c) *Rattus rattus argentiventer*, field-rat in Malaya. This rat is restricted to open grassy areas in Malaya and is the principal host of *T. akamushi* and *T. deliensis*, the vectors of scrub typhus. It is only occasionally infested by *indica* (average 1 per rat). Philip *et al.* (1949) described an experiment in a young rubber plantation with under-cover, where *E. indica* was scanty on *R.r. argentiventer* except in one subarea (ID) described as being higher and drier than the others. This particular area included the remains of an old food-store destroyed by the Japanese and since overgrown, so that much of the *indica* may have been a relict from house-rats formerly infesting the store.

(d) *Rattus rattus jalorensis*, Wood Rat, in Malaya (see *i* below). This is a semi-arboreal rat also coming down to the ground, belonging particularly to the forest fringe where the canopy descends to shrub level (Harrison, 1957). It is a major pest of plantations of rubber and oil-palms. Specimens from an oil-palm estate near Sungei Buloh carry about 37 *indica* per rat, and occasionally a few specimens of *audyi*.

(e) *Rattus* sp. in Addu Atoll, Maldives. This rat was identified in the field as *R. norvegicus* by Radford (1945) but Gardiner (1906:1049) records the rat on Addu as *R.r. alexandrinus*. It was ubiquitous over the atoll, and was frequently seen in coconut palms and running along telephone wires strung between trees, so that it was behaving like a *Rattus rattus*. These rats, taken from all parts of the island, had about 15 *indica* per rat (Kafra and Radford, personal communications, and Kafra, 1947). Adults of *E. indica* were discovered in the dead flowers and leaf debris in the tops of the coconut palms.

(f) *Rattus rattus mindanensis* (see also g below). This is the town rat of Manila, described as freely infested by *indica* by Philip & Woodward. It has been introduced to Guam where Wharton (1946) described it as abundant, especially in rain-forest, plantations and gardens, and in villages where the natives complained of these rats in their thatched roofs. The incidence of *indica* was however low among the village rats (3 infested out of 164 from Agat), which demands explanation. Although this rat occurred over most of the island, infestation by *indica* was local, being mostly in the western part of a rain-forest which encircled a plateau in the north part of the island, and also in various coconut groves. In the latter, the rat was presumably behaving like the rats on Addu and in the oil-palm estate in Malaya. *E. indica* was not found in grassy areas on the plateau, which had followed cultivation and deterioration of the soil.

ii. Forest Animals. (g) *Rattus rattus mindanensis* in forest on Guam. Wharton found that rats collected in rain-forest at Ritidion and Patay Points were not infested although the highest infestation occurred at Oca Point in similar surroundings. This remains unexplained. At Oca Point the rats were living and nesting particularly in the soil-like masses at the bases of epiphytic ferns, from which adults, nymphs, and larvae of *indica* were repeatedly recovered. Collections of fruits of *Ochrosia* were useful indicators of the presence of hiding places and burrow-entrances of the rats. Nests in or near the ground, except for two nests under the protection of logs, were generally uninfested; while nests in trees, which were apparently better drained, were freely infested.

(h) *Callosciurus tenuis* in Malaya. This small squirrel is essentially a forest tree-squirrel which may extend across the forest edge into plantations, etc. It is diurnal while the rats are essentially nocturnal. It apparently builds nests of twigs (at canopy levels?), which by local accounts are particularly in axils and tree-holes; and the range of individuals, as with squirrels generally, is likely to be significantly greater than the corresponding range of rats (Harrison, personal communication). Sixty-one *C. tenuis* from our general collections had the following average numbers of trombiculids per individual: 11 *E. "indica"*, 14 *E. audyi* with a new species *E. (L.) "CTEN"*, 2 *E. (Walchiella) oudemansi*, 3 *Trombicula spicea*, and occasionally a few other species. No other arboreal animal has so many *indica*-like trombiculids on it, but the identification of these is provisional because the 11 "*indica*" per squirrel include not only some whitish larvae indistinguishable from *indica* but also red larvae, which are morphologically so close to *indica* as to be confused with it. Further discussion is therefore profitless without more detailed taxonomic studies.

(i) *Rattus rattus jalorensis* in Malaya (see d above) from the forest fringe carries both white larvae and red larvae, the latter apparently *indica* and apparently the same as the red larvae on *C. tenuis*. Possible morphological differences are being investigated but there may be two biologically distinct forms present.

(j) Tree-shrews are as much terrestrial as arboreal. They have about 2 *indica* and 4 *audyi* per animal in Selangor.

(k) *Chiropodomys*. These are very small rats which in Malaya nest in the internodes of bamboo after making a small entrance hole and biting through some of the partitions. Specimens of a relatively large species were found on Mt. Kinabalu in Borneo by one of the joint U.S. expeditions to be not only in bamboos but also in tree-holes in dead palms. Seventy-six specimens of *C. gliroides* from Malaya were found to be uninfested, but *C. legatus* on Kinabalu is the host of *E. (L.) indicella*, *E. (L.) roluis* and *E. (L.) ocellifera*.

(l) *Rattus canus* in Malaya is a strictly arboreal rat. One hundred and twelve specimens from our general collection had an average per rat of 1 *E. indica*, 3 *E. audyi*, several of a new species *E. (L.) "CAN"*, and 19 *Ascoschöngastia malayensis*, all of which we consider to be related; and also 1 *T. spica* and 11 *E. (W.) oudemansi*.

(m) *Rattus cremoriventer*, the Pencil-tailed Tree-rat, in Malaya. This is a strictly arboreal forest rat like *R. canus* but differs sharply from it, and at the same time resembles *R. rajah* on the ground, by being infested rarely by external chiggers but moderately by intranasal ones (species "LAU" dominant). Of 172 *R. cremoriventer* examined (1949-55), only 5 were infested with ectoparasitic chiggers: 6 *Gahrliepia (G.) fletcheri*, 5 *Gahrliepia (Walchia) pingue*, 26 *E. (Walchiella) oudemansi*, 8 *E. (L.) indica*, 1 *Trombicula spica*, 1 *T. (Leptotrombidium) sp. nr. bodeusis*—i.e. only 0.28 chiggers per rat, an exceptionally low degree of infestation. Of these rats, 15 (1954-55) were also examined for intranasal species, and these had: *E. (L.) "LAU"*, 45 on 4; *E. (L.) TAA-group*, 10 on 2—i.e. about 3-4 intranasal chiggers per rat.

(n) *Rattus rajah* (Spiny Rats) in Malaya. The two colour-forms *R. rajah surifer* and *R. rajah peltax* are doubtfully separable according to Harrison (1957). These rats live on the forest floor and make burrows in the ground, with which habit we associate an unusually heavy infestation by nest-parasites such as gamasoid mites and fleas. *R. rajah* is notable for being unusually lightly infested by external trombiculids (average 3-4 chiggers per rat, mostly *G. (Walchia) pingue*), but exceptionally heavily infested by intranasal chiggers (average of 36 intranasal chiggers per rat); the results of examining 115 *R. rajah surifer* being as follows:—*Dolopsis (VN-group)*, 3441 on 61; *E. (Laurentella, TAA-group)*, 641 on 30; *G. (Walchia) pingue*, in ears, 495 on 29. A most interesting fact is that the Gambia Rat, *Cricetomys*, is, according to Vercammen-Grandjean, similarly infested by intranasal rather than external trombiculids (Audy & Vere., 1955, in which the figure of 70 is an approximation of the number of intranasal chiggers per infested *R. rajah*, not per rat). It will be noted that intranasal *Dolopsis* is particularly associated with ground-rats, while intranasal *Laurentella* is associated more with tree-rats and squirrels.

Affinities

It will be seen from the above data that this subgenus forms a fairly consistent group biologically. There is some evidence that these mites generally infest nests or their immediate environment, in contrast to such species as *T. deliensis* and *T. akanushi* which infest other parts of the hosts' ranges. Nest-infestation by the free-living stages is a specialized adaptation, and though it is not so intimate as spending the whole life-cycle on the host, it is sufficiently close for a certain degree of host-specificity to develop. There is some evidence that this might be happening in this subgenus, although extensive collections would be necessary to prove it.

An unusual example of host-specificity is that of *Ascoschöngastia malayensis*, restricted to *R. canus* and probably a nest-infesting chigger. Larvae are found deep within the auditory canal of the rat in glutinous mucoid secretion. The recession of the scutum

so as to leave the PL setae isolated is a character which has developed in various unrelated groups (e.g. intranasal *Doloxia*, Audy 1954:157). It is reasonable to suppose that *A. malayensis* has been derived from a *Laurentella* stem—it would certainly be included in *Laurentella* on larval characters if the PL setae were placed on the scutum.

The species which have been placed in the genus *Ascoshöngastia*, of which *malayensis* is the type, themselves show the same range of variation which is to be found between the *indica*-group and the *debilis*-group. The writer is at present of the opinion that *Laurentella* and *Ascoshöngastia* may prove to be congeneric (cf *Doloxia* and the VN-group, Audy 1954:157); but neither promotion of *Laurentella* to a genus nor reduction of *Ascoshöngastia* to a subgenus of *Euschöngastia* would be helpful steps to take at this stage.

The *debilis*-group, here tentatively included in *Laurentella*, has all the general characters of the *indica*-group except that the galeal seta is usually barbed, and the AM seta is placed more posteriorly so that the AL "shoulders" of the scutum are absent. Nymphs are unknown, all the three species in this group being rare. There is a general resemblance between larvae of the *debilis*-group and larvae of the genus *Pseudoschöngastia*, in which there are two special development, viz. the retraction of scutum away from the PL setae, and the fusion of the femora of legs II and III so that the legs are segmented 7.6.6, instead of the usual 7.7.7. Both these are recurrent polyphyletic characters which have been discussed by Audy (1954:125, 154).

The 7.6.6-segmentation of legs II and III, formerly considered characteristic of the Gahrlepiinae (= Walchiinae), can no longer be regarded as a subfamilial character. Both types of segmentation have been found in extremely closely related members of (a) the *Trombicula panieri* group (Audy 1954:147) in Africa and Malaya, (b) the 7.7.7 *E. lacunosa* group which should probably be included with the 7.6.6 *oudemansi*-group in *Walchiella*, and (c) *Schoutedenichia*, only the restricted *fulleri*-group of which has 7.6.6 legs (Vercammen, 1955; Vercammen & Audy, 1956). The fusion of basifemur and telofemur appears to be related in these mites to the length of the leg-segments, fusion tending to occur among the short-segmented species, and Vercammen (personal communication) has related this character to a ratio of total femoral length to width.

A further relationship is with *Euschöngastia* (*oculicola*-group) *oculicola* (Womersley), **comb. nov.** [= *Schöngastia* (*Schöngastia*) *oculicola* Womersley, 1952: 167(d), 383(dN); ?*Doloxia* (*oculicola*-group) *oculicola*, Audy, 1954:159(1), tentative allocation; *Schöngastia oculicola*, Radford 1954:267(1)]. In a discussion of relationships, Audy noted that this species was peculiar in both larva and nymph and that on the whole it shared most characters with *Doloxia*, including the intranasal VN-group (*oculicola* itself is incidentally from the conjunctival sac of rats). He therefore considered it to represent a distinct species-group (at present monotypic), of uncertain status; and he tentatively proposed to place it in *Doloxia*, *sensu lato*. In this, he was misled by a confusing number of new species showing larval convergence—and in the case of *oculicola*, also some nymphal resemblances to nymphs of *Doloxia*. These converging larval forms have since been satisfactorily sorted out into three groups: (i) certain forms, mostly intranasal, of *Laurentella*, (ii) *E. oculicola* itself, and (iii) certain forms, especially the intranasal ones, of *Schoutedenichia* (see Audy, 1956b). The chief characters leading to confusion among these larvae are (a) general reduction of scutum and gnathosome, (b) intranasal or conjunctival habitat (i.e. on mucous membranes or in relation to mucocutaneous junctions), (c) strong curved palpal claws, (d) modification of chelicers, by reduction and usually by the appearance of a medial or dorsomedial tooth, which may be fairly large as in *Doloxia* itself, (e) frequently short stumpy legs,

and (f) a constriction of the body of engorged larvae. It is now possible to say that *oculicola* is not a *Doloiisia* but is very close to *Laurentella*, in which it will doubtless be included shortly although it is premature to make such a change until the whole array of available species, larvae and nymphs, have been described. The larva of *E. oculicola* has short strongly curved palpal claws, a small chelicera with a prominent dorsomedial tooth (there are some inaccuracies in the original description and illustrations which are corrected by Womersley & Audy, 1957), while tibia III is present and there are 3 genualae I; the strong development of the AM seta of *oculicola* is reminiscent of that of *debilis*. Nevertheless, this species, and also *Schoutedenichia*, forms a link between *Euschöngastia* and *Doloiisia*; while *Doloiisia*, *Güntherana*, and particularly *Schoutedenichia*, form a link between the Trombiculinae and Gahrlepiinae, strong enough to break down most of the distinctions between the two subfamilies.

In the case of *Doloiisia* and endoparasitic forms of *Schoutedenichia*, various obvious similarities with larvae of *Laurentella* are almost certainly due to convergence rather than direct relationship, for the larvae of the former are all distinguished by the regular absence of tibia III and presence of only 2 genualae I, while the nymphs are distinguished by a generally *Gahrlepiea*-like facies, the nymphs of the latter being typically *Euschöngastia*-like.

On the other hand, *Laurentella* closely resembles the *Trombicula panieri* group of Audy 1954b:147 in both larval and postlarval characters. The chief morphological difference appears to be in the sensillae of the larvae, which are expanded in *Laurentella* and simple in the *panieri*-group. There appears to be a close phylogenetic relationship between the two groups. Although there is a natural tendency to group together chiggers with expanded sensillae and those with unexpanded sensillae, there is little doubt that expanded sensillae have arisen independently in unrelated groups.

It appears to the writer that *Laurentella*, *Ascoschöngastia*, the *oculicola*-group, and *Pseudoschöngastia* are parts of one complex which should be studied as a whole. There is a general similarity between nymphs of these groups and the writer is at present unable to distinguish nymphs of *Laurentella* from those of *Ascoschöngastia* and *Pseudoschöngastia* except at the species level.

Medical Importance

Traub *et al.* (1950) recovered the infective agent of scrub typhus, *Rickettsia tsutsugamushi* (= *R. orientalis*) from each of two pools of 30 and 50 larvae of *E. audyi* taken from two tree-squirrels, *Callosciurus nigrovittatus*, from forest near Kuala Lumpur. Their paper includes valuable discussions on the possible role of such vectors in the transmission of enzootic scrub typhus ("jungle tsutsugamushi", also discussed by Audy & Harrison 1951:389).

In the same year, Gispén (1950b) reported the recovery of the infective agent of "endemic" or "murine" flea-borne typhus, *Rickettsia mooseri* (= *R. typhi*). Five strains of this organism were recovered from 82 individual pools of 2,598 *E. indica* from house-rats in Batavia. Infections were recovered from mites taken from both *R.r. diardii* and *R. norvegicus*, while four of the positive pools were taken from rats in which no trace of infection was found (the fifth being from a rat shown to be itself infected). Gispén concludes from this that the infection must have been transmitted to the larvae through the eggs, a mode of transmission known to occur with rickettsiae in mites and ticks. If the rickettsiae penetrate the gut wall and reach organs such as the ovary, it is probable that they would also be able to reach the salivary glands at least occasionally,

in which case the mites should be capable of some degree of transmission. In investigations of the sort described by Gispén, attempts should also be made to recover rickettsiae from the epithelium of the areas in the ears on which the mites regularly feed. Since *E. indica* is a very common and very widespread parasite of house-rats in the far east, its potentialities as a vector of any pathogen should be investigated further.

Summary

1. A new subgenus, *Laurentella*, is raised to accommodate those trombiculid mites hitherto contained in the 'indica-group' of *Euschöngastia*, sensu lato, together with a *debilis*-group and a third group comprising certain undescribed endoparasitic species which have a modification of leg III. Over 22 species, including one from Africa, are ascribed to this subgenus: of these, 12 have been described and are here listed together with synonyms, references, new records, and some discussion on taxonomy and distribution.

2. The type species, *Euschöngastia (Laurentella) indica*, is extremely widespread and occurs particularly on domestic rats in most urban areas from India to New Guinea and the Philippines. Another species, *E. (L.) audyi* is a dominant chigger on tree-living mammals from Malaya and Borneo.

Rickettsiae responsible for non-epidemic forms of typhus infection have been recorded from both these common species, which may therefore be of importance in transmitting infection among their animal hosts.

3. It is considered that *Laurentella*, *Euschöngastia oculicola*, and the genera *Ascoschöngastia* and *Pseudoschöngastia* form a complex which should be studied as a whole. It is also considered that *Laurentella* has a common origin with the *Trombicula panzeri* group.

4. Observations are made on the biological and zoogeographical interest of members of this genus, and their host-relationships are discussed. There appears to be some general association with nests of hosts, leading to a degree of host-specificity which is not common among trombiculids. One species, *E. (L.) soekaboemiensis*, shows a break in distribution across the body of Malaya, in common with a number of animals and arthropods. At least 5 species awaiting description have been found to be endoparasitic in the nasal cavities of rats in Malaya and Borneo.

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* Those marked with an asterisk have not been consulted by the writer.

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